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Proposal for an experiment at SC to search for $\pi\pi$ interaction at low energy.

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Introduction.

The experimental situation concerning the $\pi\pi$ interaction at low energy and in the S state has not yet been settled. In a well known experiment performed in Berkeley[1], a striking anomaly in the He^3 spectrum in the p + d reaction has been found leading to the hypothesis of a strong $\pi\pi$ interaction at threshold and with T = 0. Such a result seems hard to reconcile with the indications coming from the theoretical interpretation of the tau decay[2] and with the energy dependence of pion production in pion - nucleon collisions near threshold[3].

Several experiments have attempted to observe such an anomaly (referred to hereafter as ABC) both in photoproduction and in π-p collision. Table I shows the results of these attempts. The last two experiments in the list show the ABC decaying into two charged particles.

We are here proposing an experiment to search for the anomaly by studing the process

$$\pi^- + p \rightarrow n + \pi^+ + \pi^- \qquad 1)$$

at an incoming pion energy of about 280 MeV ($\pm$ 3%) and looking at the mass spectrum associated with the $\pi^+\pi^-$ system.

Given the low energy at which the two pions are produced we hope to concentrate on the following problems:-

1) If the ABC anomaly is there we want to measure its width with good resolution and, possibly, the variation of its properties as function of the incoming pion energy.

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2) In case the ABC (as it seems) is a resonance in the physical region it may decay in to 2 pions or 2 pions plus a γ ray, according to its G parity; it is generally expected that such a resonance will have positive parity. This can be checked with our apparatus.

3) If the width of the resonance is narrow enough to exclude the presence of a strong final state interaction between the pions and the nucleon, the angular distribution of the 2 pions can give information on the spin of such a dipion state.

If one selects ABC's emitted in the very forward direction, the neutron will take a negligible (5 - 10 MeV) recoil energy. This means that the total energy of the $\pi\pi$ system is pratically fixed, being close to the total energy of the incident pion (415 MeV). The angle between the two final pions is a very sensitive function of the kinetic energy of the two pions in the ABC rest system, that is $T = m_{ABC} - 2m_{\pi}$. Detailed calculations (Figs. 1 and 2) show that, for the cases we would like to select, by measuring the energies of the two pions within, say $\pm$ 5 MeV and the opening angle within $\pm 1^{o}$, T can be determined as accurately as (2 - 3) MeV ($290 < m_{ABC} < 340$ MeV).

Experimental set up.

The experimental set up is shown in fig. 3.

The beam (280 - 300 MeV) is prepared in a way similar to that devised by W. Middelkoop et al. (private communication), and it seems reasonable to expect in this range of energies around $5\ 10^{4}$ π^{-} per second.

To trig ger the spark chambers the following conditions are asked.

a) coincidence $12\bar{3}$ to define an interaction in the target together with

b) at least one charged particle in each of the counters 4, 5, 6, (see fig. no. 1) and no particle in counter 7

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c) moreover counter 4 has to give another pulse, fairly monochromatic, and delayed with respect to ($12\bar{3}4$) coming from the decay product of the stopped positive pion ($\pi^+ \to \mu^+$).

We hope to be able to recognise 1/3 of the π^+ stopped in counter 4.

Under these conditions reaction (1) should be strongly selected against the other possible competitive ones, namely

$$\pi^- + p \to \pi^- + p \qquad 2)$$

$$\pi^- + p \to \pi^0 + \pi^- + p \qquad 3)$$

$$\pi^- + p \to \pi^0 + n \qquad 4)$$

by the demand of a stopped π^+ (in counter 4) and the geometrical arrangement of the counters.

Both π^- and π^+ from reaction (1) enter the thin plate spark chamber (No.1) which is here used to measure the angle between the two charged particles.

The spark chamber No.2 will be a range spark chamber and it is meant to measure the range of the negative pion (the energy of which varies between 30 and 60 MeV).

The range of the π^+ entering counting No. 4 will be given by the pulse amplitude of the counter, the thickness of which is about 10 gr/cm^2.

The selected π^+ produced in reaction (1) have an energy which varies between 60 and 90 MeV. Thus we select preferentially the ABC (if it exists) as the decay angle between the two pions is around 50^o. (See fig.No.2.) The maximum opening angle between two particles produced in the target that our apparatus is able to accept is about 100^o.

Assuming a $\left.\frac{d\sigma}{d\Omega}\right|_{=0}$ for ABC production of the order of 10μb/ster we expect about 10 ABC's per hour, having assumed the following parameters

Incident π^- flux $5 \cdot 10^4$/second

Energy of π^- between 280 and 300 MeV

Solid angle counter No.4 $2.10^{-2}.4\pi$ ster

Counter No.5 50 x 40 cm^2

π^+ detection efficiency ~ .3

For this experiment we need

a) machine time to prepare the beam

b) machine time to test the π^+ detector, the electronics and the spark chambers 20 shifts

c) machine time for data taking 30 shifts

REFERENCES

1) A. Abashian et al. P.R.L. 7, 35, (1961)

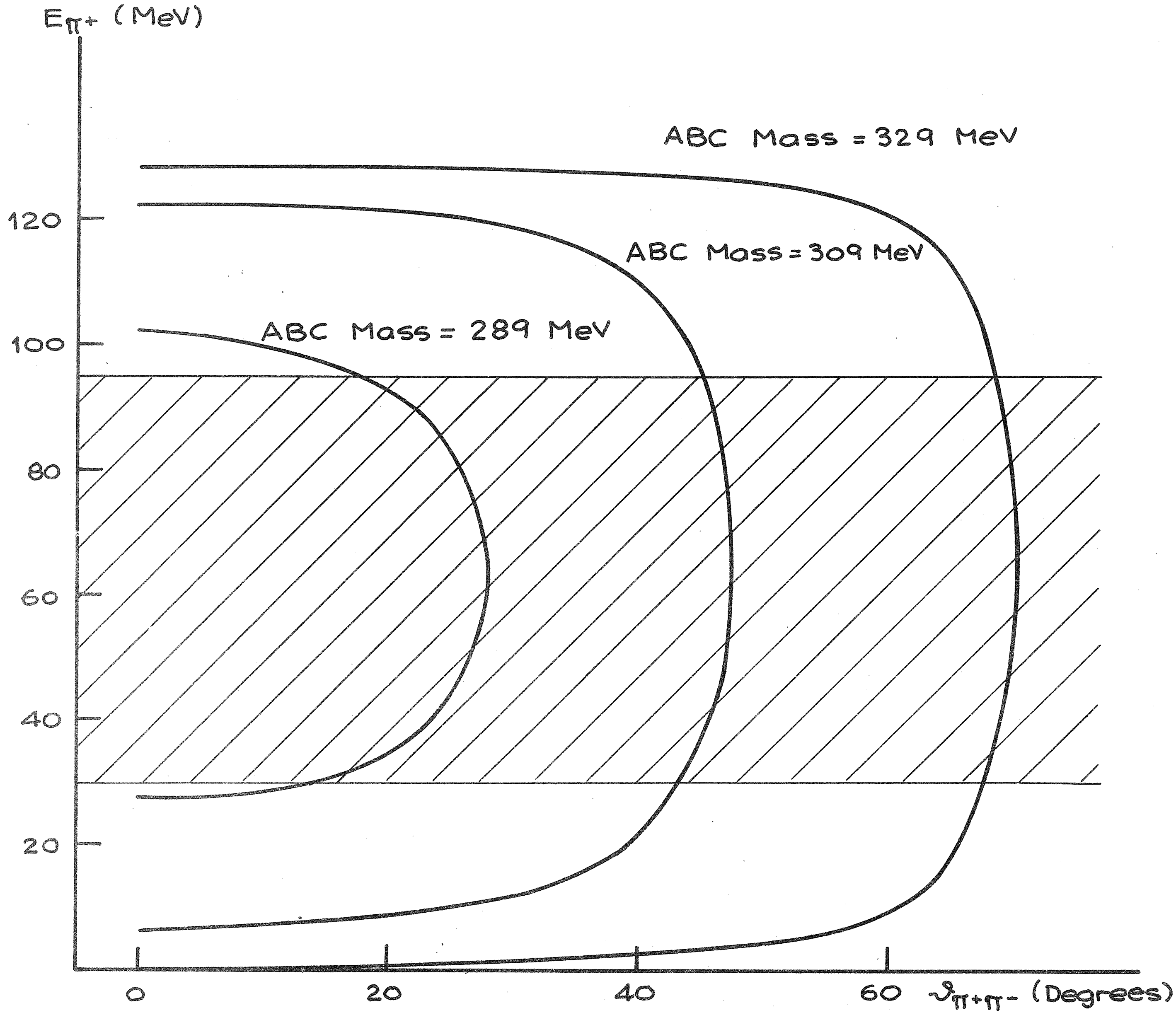
2) N.N. Khuri and S.B. Trieman P.R. 119, 1115 (1960)
R.F. Sawyer and K.C. Wali P.R. 119, 1492 (1960)

3) C. Ceolin and R. Stroffolini CERN - 2114 - TH 212

4) W. Middelhoop (private communication).

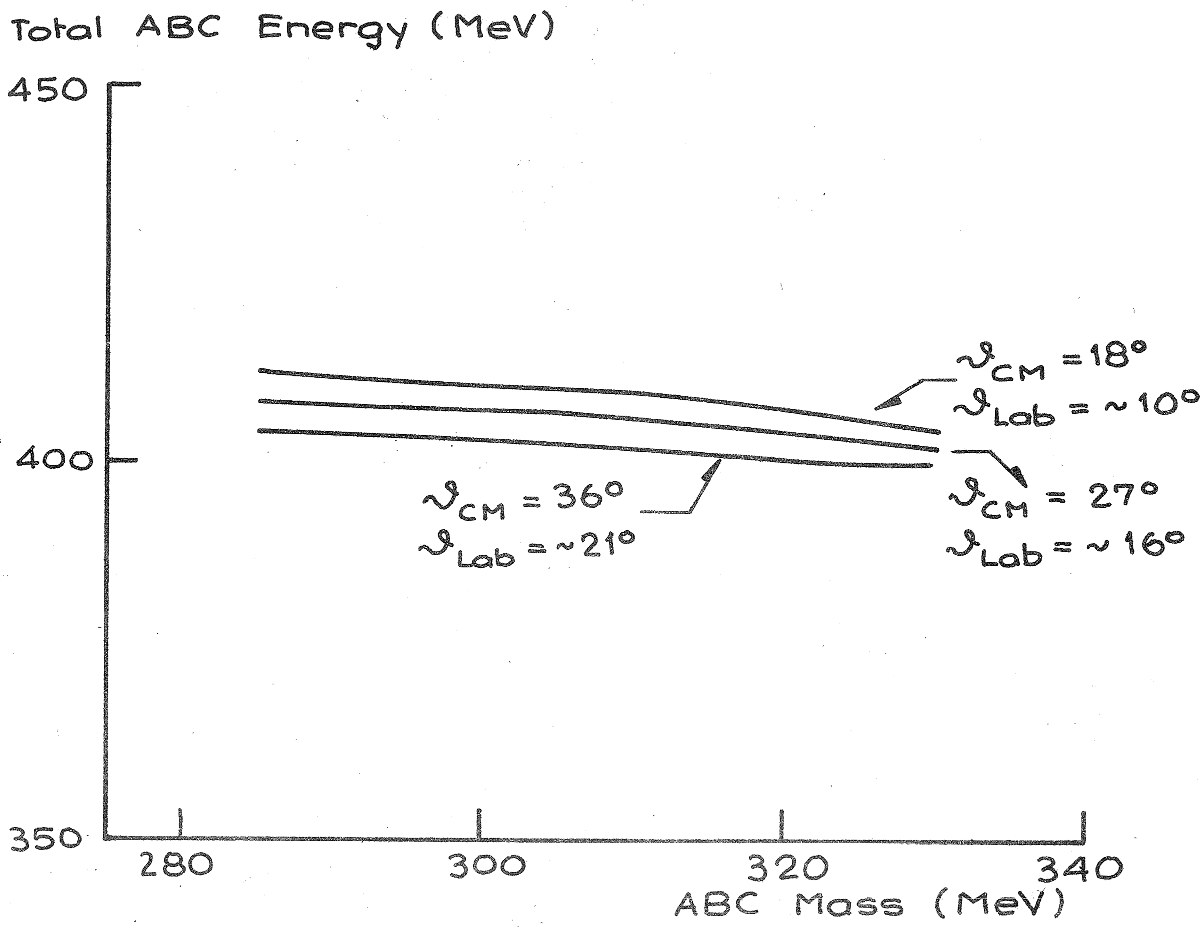
TABLE 1

AUTHORS	REACTION	CROSS-SECTION cm^2	RESULT	DETECTED PARTICLES
Berkelmann et al. P.R.L. 6 234 (1961)	$\gamma + p \rightarrow (ABC)+p \rightarrow \pi^+ + \pi^- + p$	$< 5\ 10^{-32}$/st.	no effect	proton + π^+
Gomez et al P.R.L. 5, 170 (1960)	$\gamma + p \rightarrow (ABC)+p \rightarrow p + \pi^0 + \gamma$	$< 3\ 10^{-31}$/st.	no effect	proton + γ's
Bernardini et al. N.C. 14, 268 (1959)	$\gamma + p \rightarrow (ABC)+p$	$< 3\ 10^{-31}$/st.	no effect	proton recoil
Middelkoop et al. CERN (1961)	$\pi^- + p \rightarrow (ABC)+n \rightarrow n+\pi^0 + \gamma$	$< 5\ 10^{-28}$	no effect	neutron + γ's
Richter Stanford preprint	$\gamma + p \rightarrow (ABC)+p$	$=(7.5 \pm 2)10^{-31}$/st.	effect (?)	proton
Stoppini et al. Frascati (private pre-print) and SIF communication	$\gamma + p \rightarrow (ABC)+p \rightarrow p+\pi^+ + \pi^-$	$\sim 10^{-31}$/st.	effect (?)	proton $\rightarrow$ both π's
Abashian et al. P.R.L. 7, 35 (1961)	$p + d \rightarrow He^3 + (ABC)$	$4\ 10^{-31}$/st.	effect	He^3
J. Button et al P.R. 126, 1858 (1962)	$p + \bar{p} \rightarrow 2\pi^+ + 2\pi^- + \eta\pi^0$ (bubble chamber)		effect	charged π's



$(ABC) \rightarrow \pi^+ + \pi^-$
Decay Kinematics
Positive Pion Energy
VS Angle between Pions
Total Energy : 409 MeV

Fig. 1



$\pi^- + p \rightarrow (ABC) + n$

Incident π^- Energy = 280 MeV

ABC total Energy

VS ABC Mass

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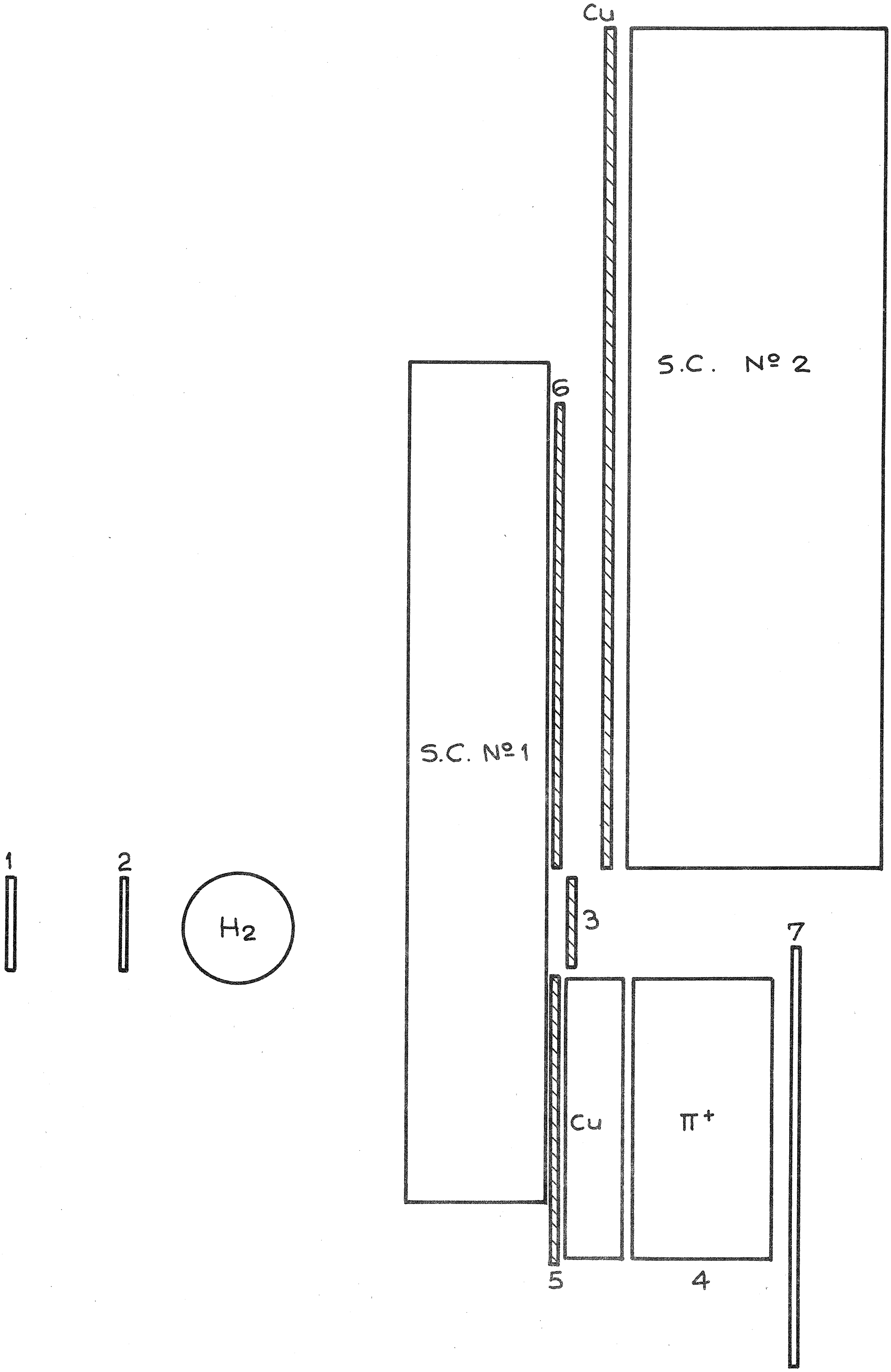
Fig. 2

Fig. 3. TOP VIEW



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